California Energy Commission

- Energy Efficiency Standards for Buildings and Appliances
- Implementation of CA's Renewable Electricity Standard
- Transportation and Liquid Fuels
- Energy Forecasting
- Research
- Power Plant Licensing

California's Climate Emissions Goals

- Climate Solutions Act (AB 32) enacted in 2006
- Return to 1990 levels by 2020 (approx. 30% reduction from Business as Usual)
- Governor Schwarzenegger's Executive Order calls for 80% reduction by 2050

California GhG Reductions by 2020

- Total Reduction needed = 174 MMT CO^2E
- ~ 50 MMT from increased vehicle efficiency
- ~ 50 MMT from electricity-sector efficiencies

  - Building and appliances

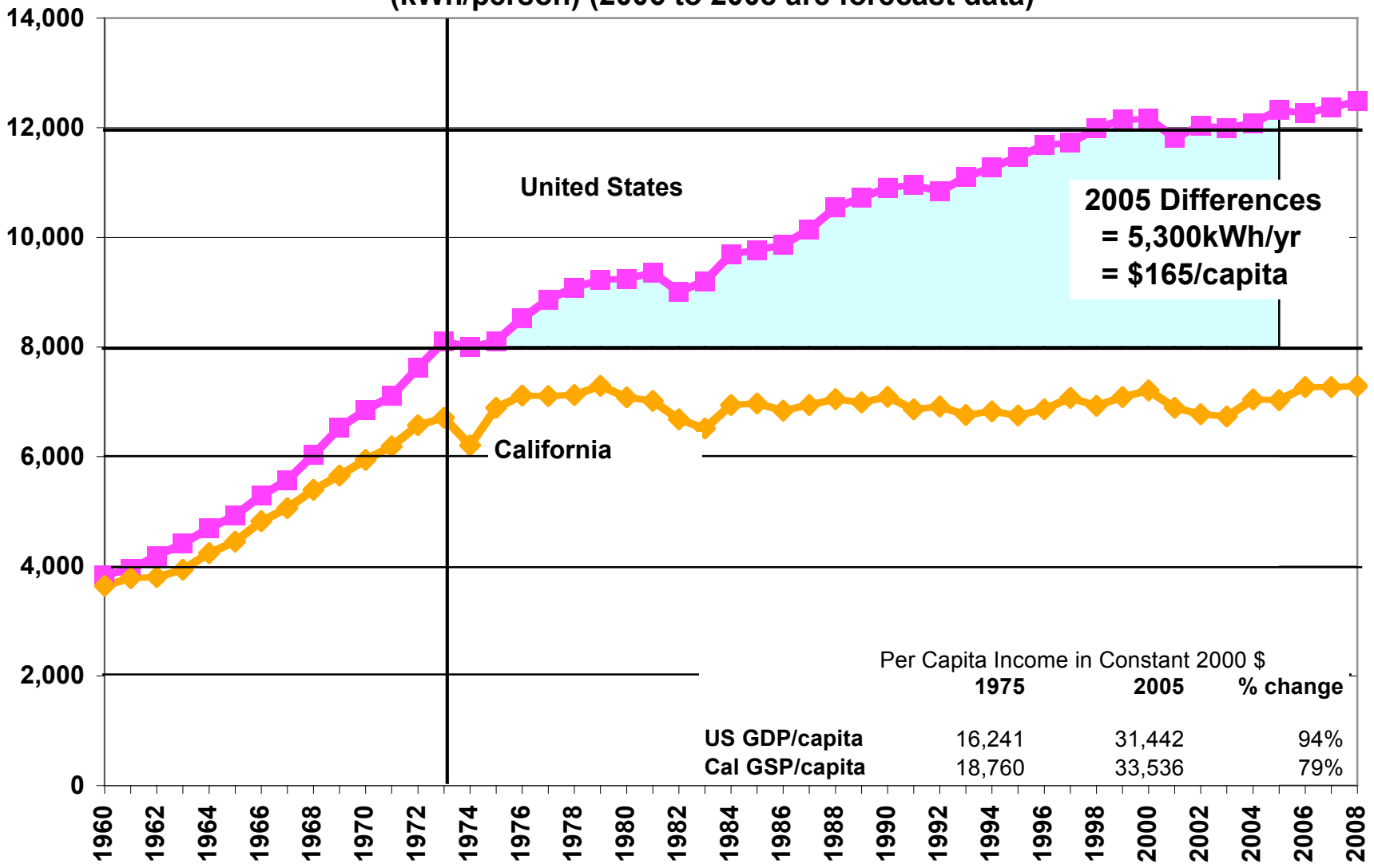
  - Water efficiency and solar water heating

  - Combined heat and power

Energy Efficiency in California

- "Decoupling" of utility profits from volume of energy sold
- Energy Efficiency Standards for Building and Appliances
- Public Goods Charge – 3% of utility bills
- Utility rebate and public education programs
- Vehicle emissions/efficiency (AB 1493) passed in 2002 and now adopted nationally
- Water efficiency standards / programs
- Transmission ("Smart Grid")

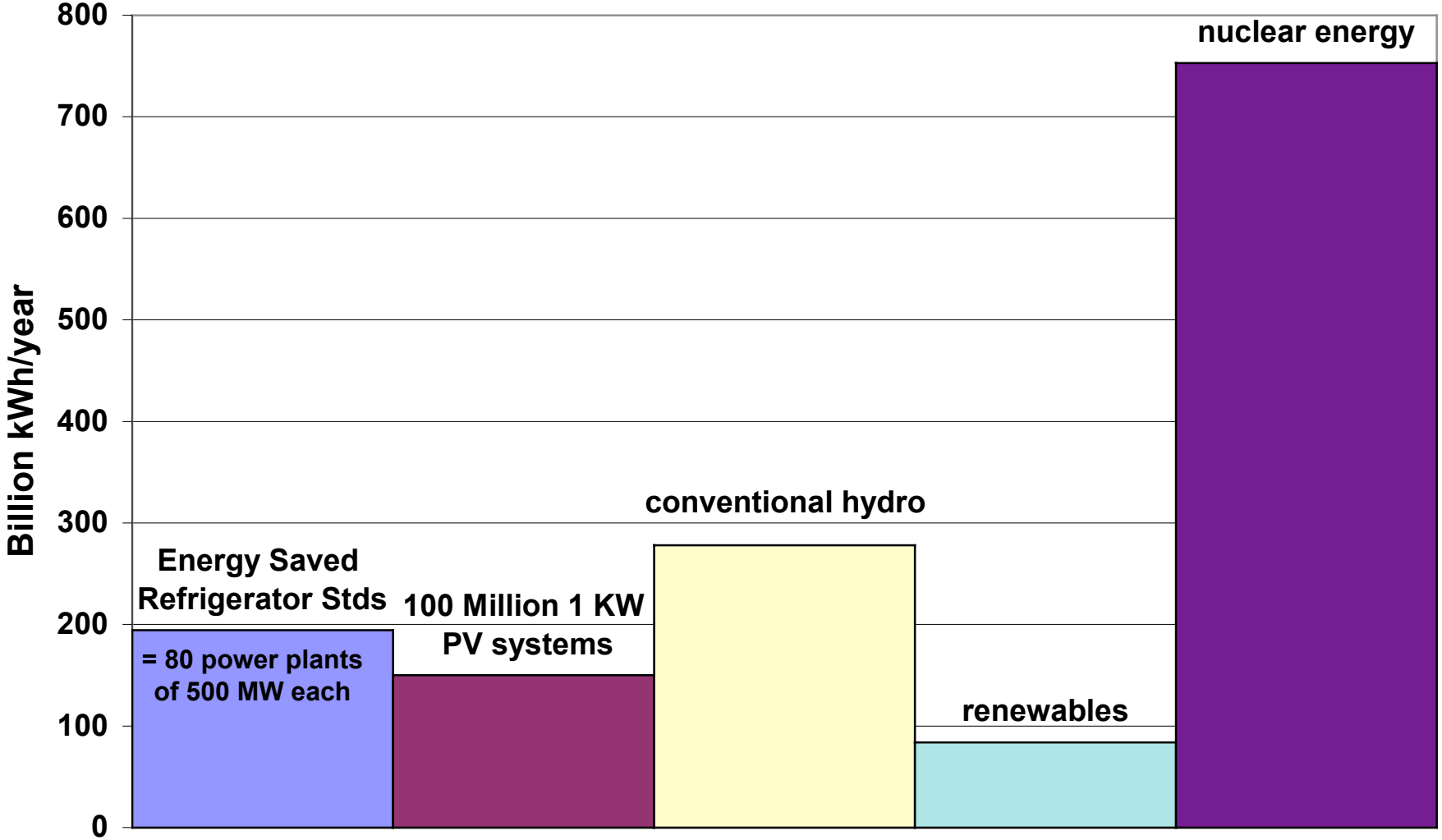
Per Capita Electricity Sales (not including self-generation) (kWh/person) (2006 to 2008 are forecast data)



Per Capita Income in Constant 2000 $

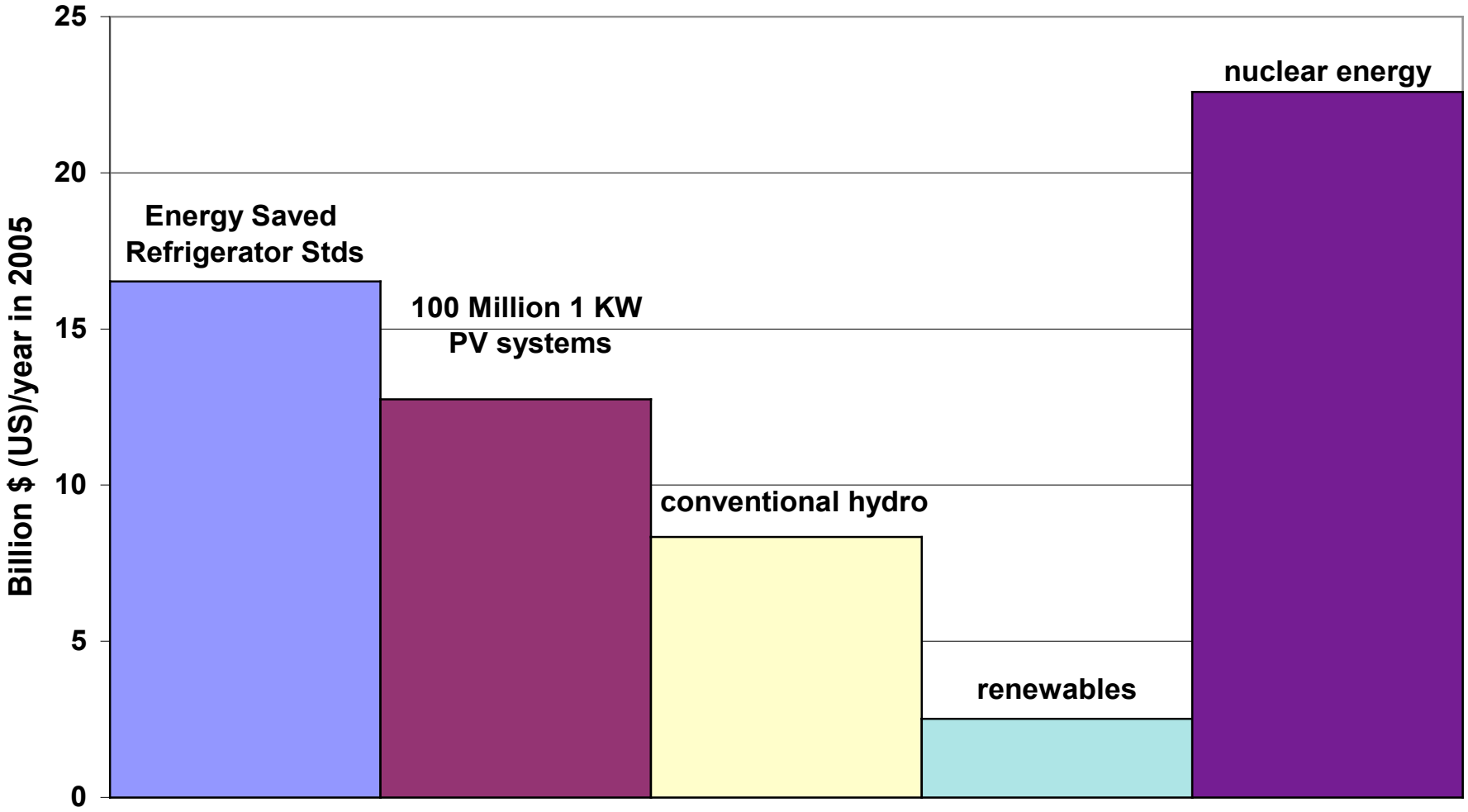
	1975	2005	% change
US GDP/capita	16,241	31,442	94%
Cal GSP/capita	18,760	33,536	79%

Annual Energy Saved vs. Several Sources of Supply In the United States

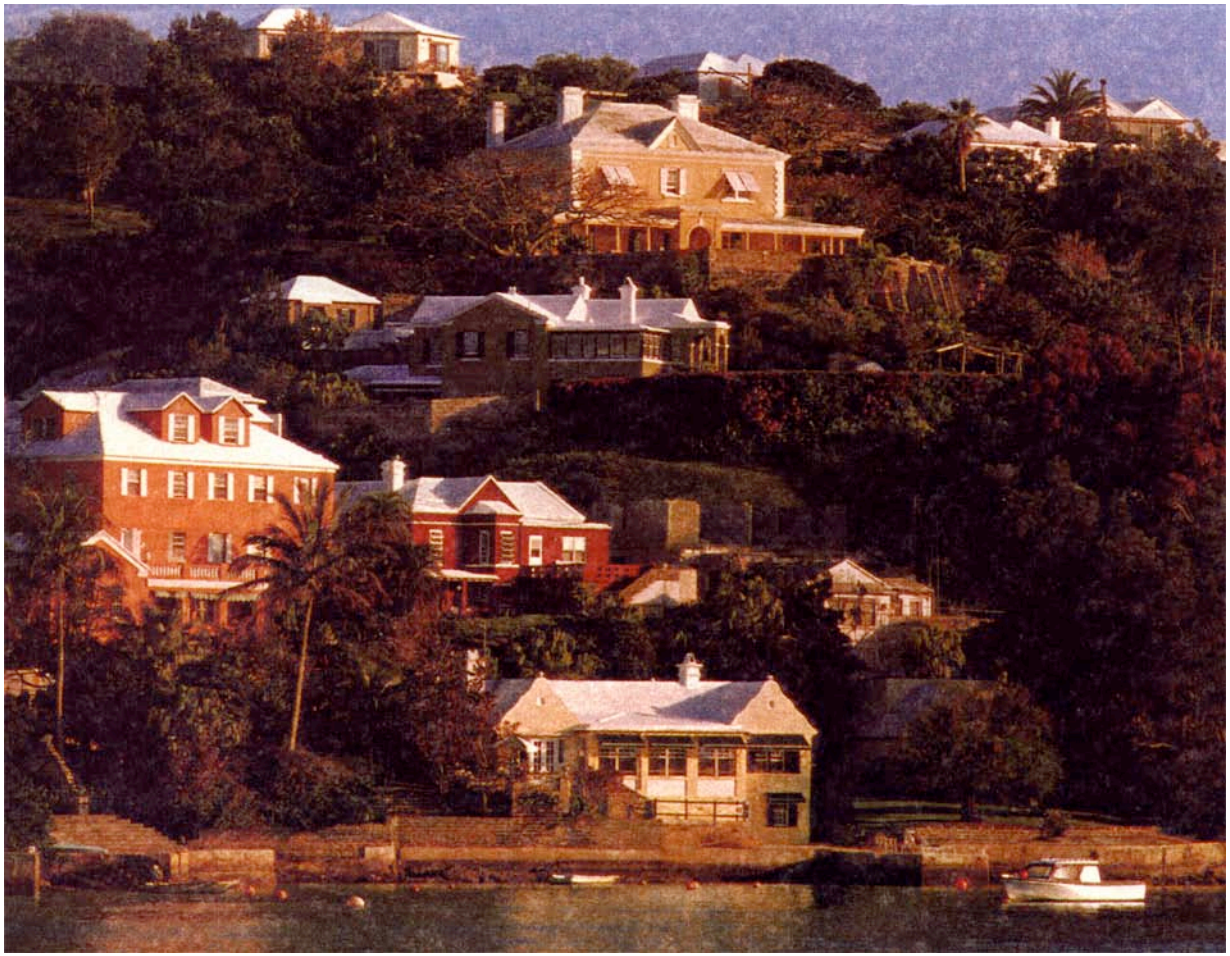


In the United States

Value of Energy to be Saved (at 8.5 cents/kWh, retail price) vs. Several Sources of Supply in 2005 (at 3 cents/kWh, wholesale price)



White is ‘cool’ in Bermuda



and in Santorini, Greece

Cool Roof Technologies

Old

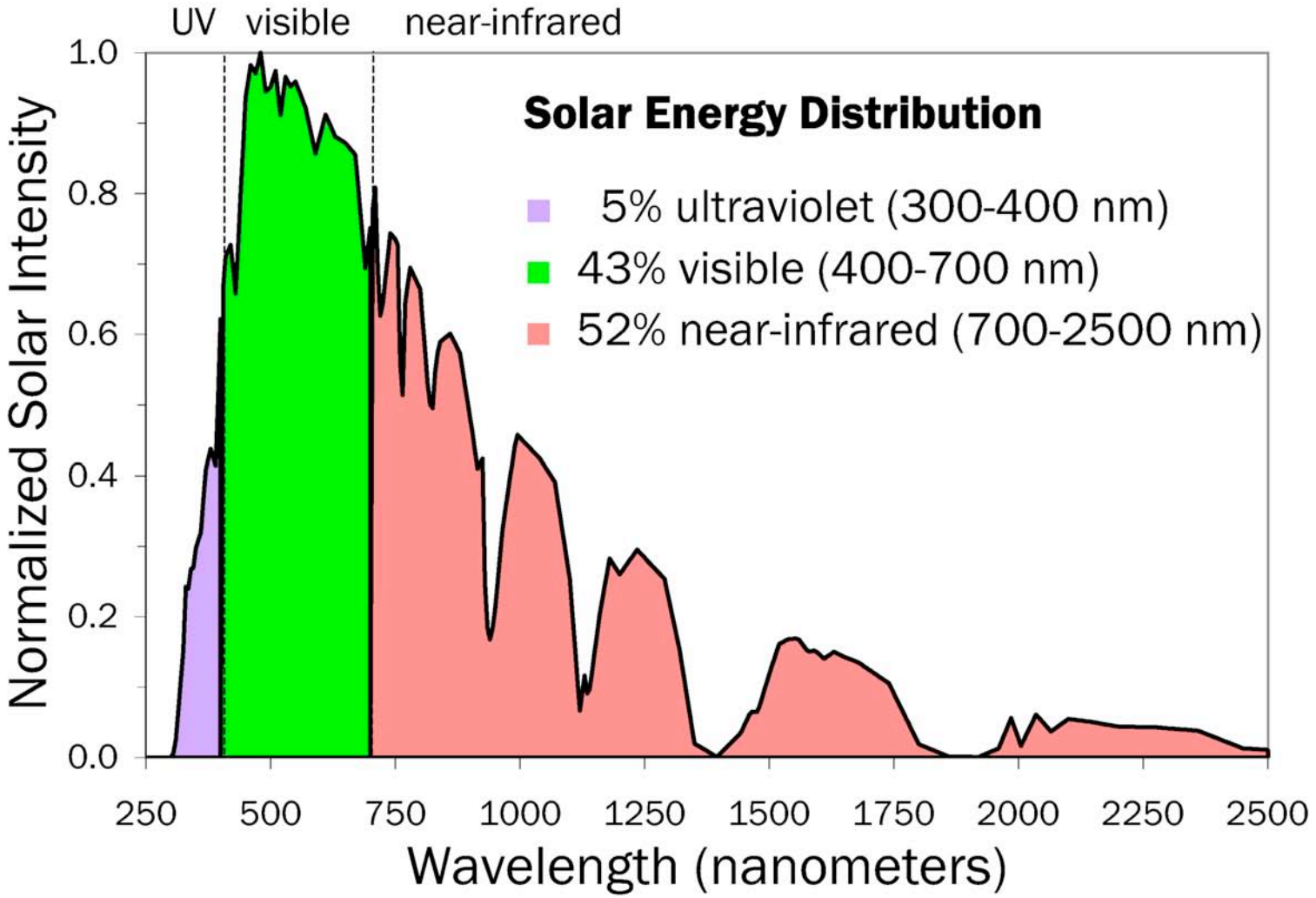
flat, white

pitched, white

New

pitched, cool & colored

Cool Colors Reflect Invisible Near-Infrared Sunlight



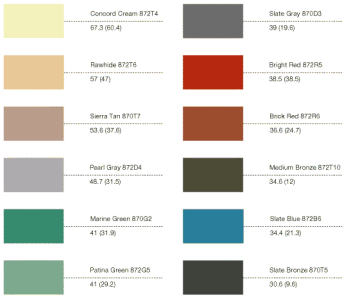
Designing Cool Colored Roofing

	black	blue	gray	terracotta	green	chocolate
cool concrete tile R ≥0.40	R=0.41	R=0.44	R=0.44	R=0.48	R=0.46	R=0.41
standard concrete tile (same color)	R=0.04	R=0.18	R=0.21	R=0.33	R=0.17	R=0.12
solar reflectance gain =	+0.37	+0.26	+0.23	+0.15	+0.29	+0.29

Courtesy American Rooftile Coatings

cool clay tile
R ≥0.40

Courtesy
MCA Clay Tile



cool metal
R ≥0.30

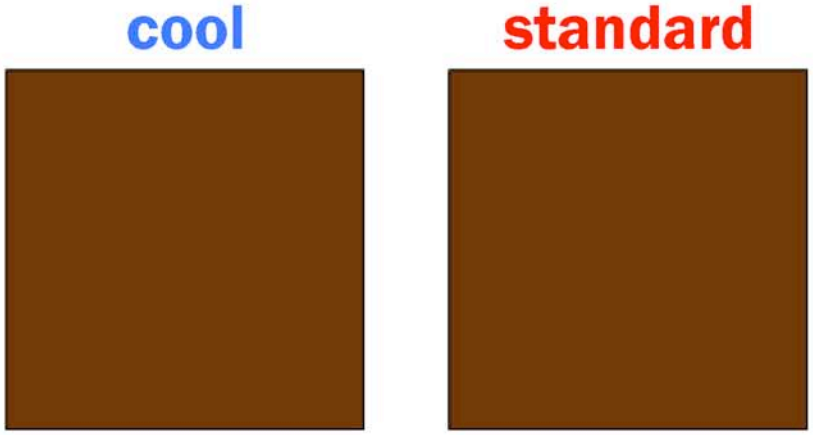
Courtesy
BASF Industrial Coatings

cool fiberglass asphalt shingle
R ≥0.25
Courtesy
Elk Corporation

Cool and Standard Brown Metal Roofing Panels

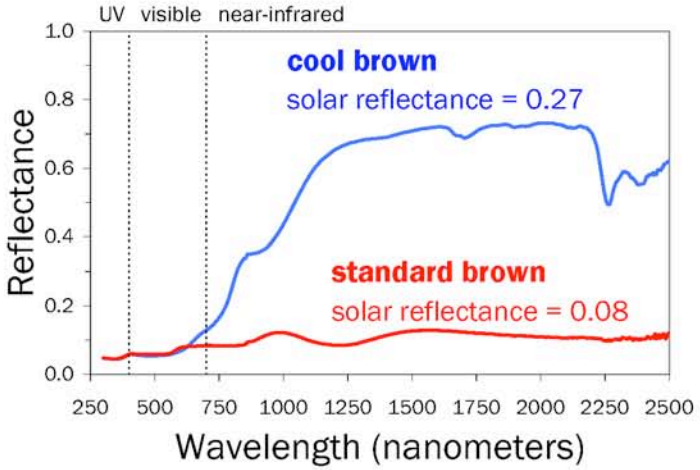
- Solar reflectance ~ 0.2 higher
- Afternoon surface temperature ~ 10ºC lower

Courtesy BASF Coatings

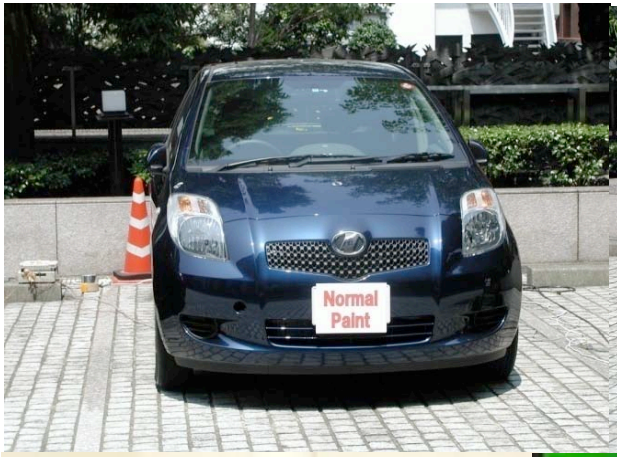


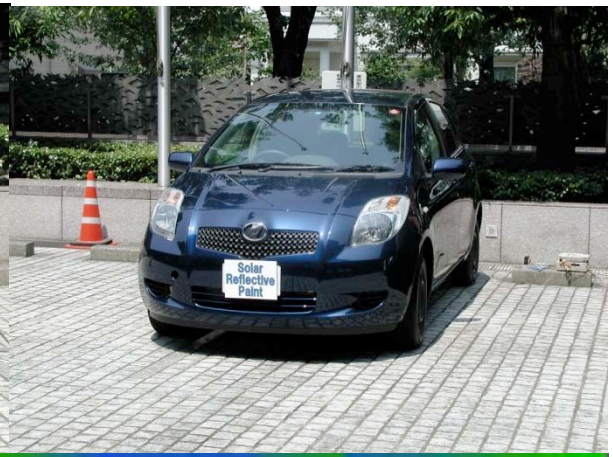
solar reflectance = 0.27
thermal emittance = 0.85
roof temp – air temp = 36ºC (65ºF)

solar reflectance = 0.08
thermal emittance = 0.85
roof temp – air temp = 45ºC (81ºF)



Cool is Cool: From Cool Color Roofs to Cool Color Cars and Cool Jackets





- Toyota experiment (surface temperature 10K cooler)
- Ford is also working on the technology

Courtesy: BMW **(http://www.ips-innovations.com/solar_reflective_clothing.htm)**

Cool Paving Materials:

Concrete	**(a)** Unexposed	**(b)** Weathered	**(c)** Weathered, wetted	**(d)** Soiled	**(e)** Abraded	**(f)** Formed
C1:S1:R2 gray cement/ riverbed sand/ granite rock	ρ=0.44	ρ=0.34	ρ=0.14	ρ=0.43	ρ=0.24	ρ=0.25

Reflective Pavements are Cooler

- **Fresh asphalt**

Albedo: 0.05
Temperature: 123°F

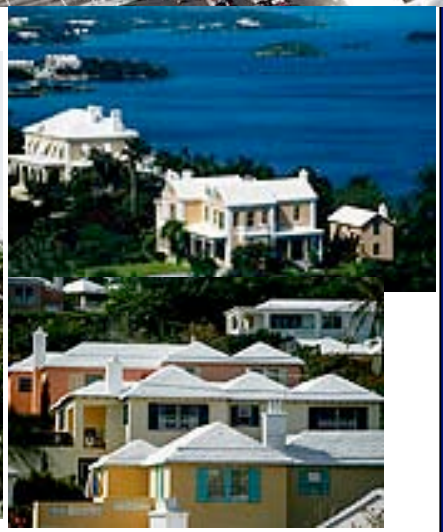
- **Aged asphalt**

Albedo: 0.15
Temperature: 115°F

- **Prototype asphalt coating**

Albedo: 0.51
Temperature: 88°F

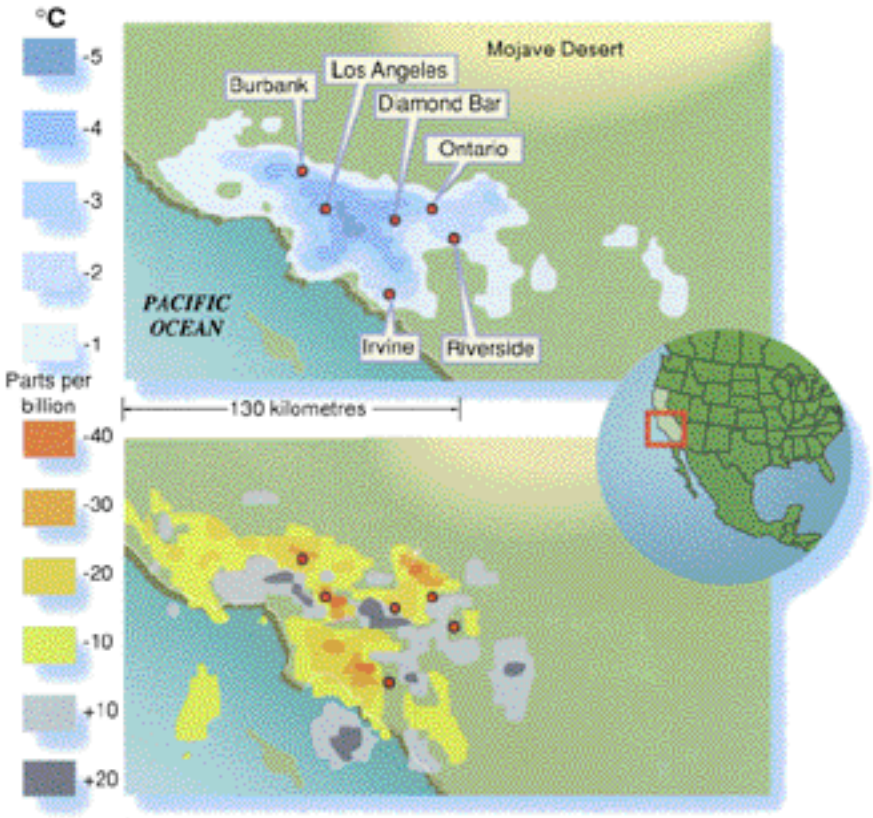
Replacing 100m^2 (~1000 ft^2) of dark roof with white roof offsets the emission of 10 tonnes of CO_2



Simulated Meteorology and Air-quality Impacts in LA

Temperature Change

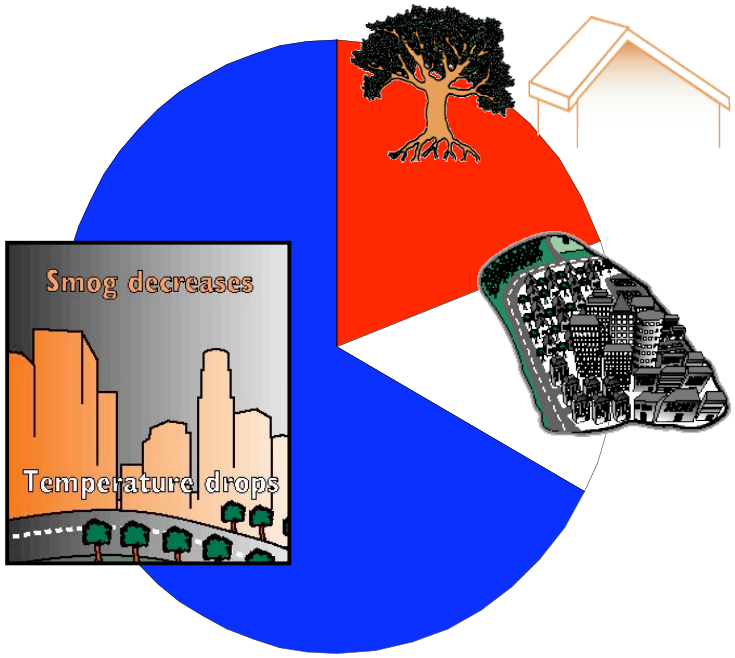
Ozone Concentration Change



Potential Savings in LA

- **Savings for Los Angeles**
  - Direct, $100M/year
  - Indirect, $70M/year
  - Smog, $360M/year

- **Estimate of national savings: $5B/year**



CO_2 Equivalency of Cool Roofs

- White Roofs alone offset 24 GT CO2
- Worth > €600 Billion
- **So rate is 300 Million cars Off The Road for 20 years.**

Cool Surfaces also Cool the Globe

- Cool roof standards are designed to reduce a/c demand, save money, and save emissions. In Los Angeles they will eventually save ~$100,000 per *hour*
- Annual savings in the U.S. = $1-2B; ~ 7 M tons CO_2
- Annual savings in the world = $10-15B; ~ 100 M tons CO_2
- But higher albedo surfaces (roofs and pavements) directly cool the world quite independent of avoided CO_2.

Resources

- California Energy Commission Website:
  - http://www.energy.ca.gov
- California Public Utilities Commission Website:
  - http:// www.cpuc.ca.gov
- Energy Action Plan:
  - http://www.energy.ca.gov/energy_action_plan/index.html
- Efficiency, Demand Response, and Renewables Programs:
  - http://www.energy.ca.gov/efficiency/index.html
- California Climate Change Efforts:
  - http://www.climatechange.ca.gov/
- Demand Response Research Center
  - http://www.drrc.lbl.gov

Special Thanks to:

- **Arthur Rosenfeld and David Hungerford**
  California Energy Commission

- **Hashem Akbari and Surabi Menon**
  Lawrence Berkeley National Laboratory

"Opportunities in the Building Sector: Managing Climate Change," Rosenfeld, A. & McAuliffe, P. Physics of Sustainable Energy: Using Energy Efficiently and Producing it Renewably, Edited by D. Hafemeister, et.al., American Institute of Physics Conference Proceedings, Vol. 1044, p. 3, 2008, College Park, MD

- http://rael.berkeley.edu/files/apsenergy/